DOCUMENT RESUME

ED 070 300 EM 010 593

AUTHOR Rigney, Joseph W.; Towne, Douglas M.
TITLE Research in Computer-Aided Performance Training. Final Report.
INSTITUTION University of Southern California, Los Angeles. Dept. of Psychology.
SPONS AGENCY Office of Naval Research, Washington, D.C. Psychological Sciences Div.
PUB DATE Oct 72
NOTE 17p.; See Also Em 010 592

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS Abstracts; *Computer Assisted Instruction; Computers; *Digital Computers; Learning Theories; Literature Reviews; *Man Machine Systems; Motivation Techniques; Research Projects; *Simulation; Training Objectives; *Training Techniques
IDENTIFIERS *TASKTEACH

ABSTRACT

The principal emphasis of this three-year research program was on developing better ways to utilize the power of the digital computer in computer-aided performance training. Two large programs, collectively called TASKTEACH, were developed and tested. These programs combined simulation and gaming techniques. The dialog with the student is sustained without using a computer-assisted instruction (CAI) language. These programs were tested to identify features needing further refinement and to test student acceptance. A second part of the research was concerned with assembling and analyzing studies in the literature bearing on theoretical issues in CAI. Topics included motivating students in training environments, specifying training objectives, evaluating effectiveness of CAI, and recent developments in learning theory and cognitive psychology. Abstracts of technical reports on these subjects are included, along with a summary of a report on TASKTEACH. (JK)

Final Report

RESEARCH IN COMPUTER-AIDED PERFORMANCE TRAINING

October 1972

Joseph W. Rigney
Douglas M. Towne

Prepared for

Personnel and Training Research Programs
Psychological Sciences Division
Office of Naval Research

Contract N00014-67-A-0269-0012

Contract Authority Identification No. NR 154-295

DEPARTMENT OF PSYCHOLOGY
UNIVERSITY OF SOUTHERN CALIFORNIA

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified.

1 ORIGINATING ACTIVITY (Corporate author) Behavioral Technology Laboratories University of Southern California Los Angeles, California 90007	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3 REPORT TITLE

RESEARCH IN COMPUTER-AIDED PERFORMANCE TRAINING

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report October 1972

5 AUTHOR(S) (First name, middle initial, last name)

Joseph W. Rigney
Douglas M. Towne

6 REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO OF REFS
September 1972	8	0

8a CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S)
N00014-67-A-0269-0012 b PROJECT NO NR154-295 c d	Final Report 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10 DISTRIBUTION STATEMENT

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11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
	Personnel and Training Research Programs Psychological Sciences Division Office of Naval Research

13 ABSTRACT

During the three-year period of this contract, the principal emphasis of the research was on developing better ways to utilize the power of the digital computer in computer-aided performance training. Two large programs were developed and tested. The approach taken in these programs combines simulation and generative techniques. The dialogue with the student is sustained without using a "CAI language." (U)

Other research interests related to motivating students in training environments, specifying training objectives, evaluating effectiveness of CAI, and recent developments in learning theory and cognitive psychology (U)

Six technical reports, one publication, and several papers for meetings were produced. (U)

DD FORM NO. 1473 (PAGE 1)

S/N 0101-807-6801

Unclassified

Security Classification

KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
CAI						
Motivation in training						
Assessment of training outcomes						
Measuring change						
Training objectives in CAI						

ACKNOWLEDGMENTS

The continued support of Dr. Glenn L. Bryan, Dr. Victor Fields, and Dr. Marshall Farr, during the period of this contract, is gratefully acknowledged. The interest expressed by Mr. Robert Cushing, Chief Educational Advisor, U.S. Naval Schools Commands, Treasure Island, is appreciated.

In the early development of problem logic, the Stanford Research Institute, Menlo Park, provided valuable assistance in unravelling the mysteries of LISP as well as time-sharing facilities for running the LISP programs.

The contributions of different BTL personnel were essential to the success of the research. Dr. Douglas M. Towne created the original LISP programs and all the subsequent extensions of this logic in less esoteric languages. Mrs. Carole King wrote the program for teaching operating procedures. Mr. D. K. Morrison programmed portions of the other TASKTEACH program in FORTRAN IV. Dr. Nicholas A. Bond scanned through the literature for information about and wrote technical reports bearing on theoretical issues in CAI. Mr. Louis A. Williams designed and made the ASCII decoder that was used for operating a random access slide projector. Mr. Edward T. Langston performed the analyses of the AN/SPA-66 and the AN/URC-32 devices and prepared material for data modules used in the programs.

ABSTRACT

During the three-year period of this contract, the principal emphasis of the research was on developing better ways to utilize the power of the digital computer in computer-aided performance training. Two large programs were developed and tested. The approach taken in these programs combines simulation and generative techniques. The dialogue with the student is sustained without using a "CAI language."

Other research interests related to motivating students in training environments, specifying training objectives, evaluating effectiveness of CAI, and recent developments in learning theory and cognitive psychology.

Six technical reports, one publication, and several papers for meetings were produced.

RESEARCH IN COMPUTER-AIDED PERFORMANCE TRAINING

This research was guided by the thesis that different ways of utilizing the potential of data-processing technology for training and education should be explored before CAI becomes a narrow orthodoxy and this potential is never fully realized. It was an assumption that costs of using this technology would, in the long run, be reduced to the point that education could be provided almost as cheaply and distributed to society almost as well as electric power now is provided and distributed.

In the short period of three years, developments in electronics, computers, and programming have been announced that encourage us in our view, and emphasize more strongly than ever the need to find better ways to use this potential to understand and to control learning and memory processes in education and training environments.

During the three-year period, research was performed in the area of computer-aided performance training. The major part of the research was devoted to designing, programming, and refining computer programs to create individualized learning environments that provide students with opportunities to develop fluency in performing troubleshooting and operating tasks involving electronic equipment. Two large programs, collectively called TASKTEACH, resulted from this work. The fundamental logic for simulating equipment and task structures and responding to the individual student in the program-student dialogue, was created with LISP 1.85. This logic was extended to include teaching the student to

set controls on front panels to obtain symptoms of malfunctions from front panel displays, and to monitoring the student's actions on front panels. This extended logic will handle any known combination of multiple control settings. The original logic for teaching operating tasks also was extended to encompass more different kinds of sequence constraints in the performance of actions and in the attainment of subgoals.

These programs were tested on small samples of students from Naval Training Commands and local trade schools, to identify features needing further refinement and to test student acceptance.

An ASCII decoder was designed and built to convert serial ASCII coming out of an acoustic coupler to a parallel form used to operate a random-access slide projector under program control.

A second part of the research was concerned with assembling and analyzing studies in the literature bearing on theoretical issues in CAI. Topics included motivating students in training environments, specifying training objectives, evaluating effectiveness of CAI, and recent developments in learning theory and cognitive psychology.

The TASKTEACH programs were demonstrated to the Electronics Schools staff, Naval Training Commands, Treasure Island, and to visitors from the Air Force and from several foreign countries.

During this period, a NATO Advanced Study Institute was given at the Royal Naval College, Greenwich, England, on the uses of computers in CAI. The Institute featured on-line practice in writing programs in BASIC, ALGOL, and FORTRAN, and was attended by approximately 70 students from most of the European nations.

Six technical reports, one publication in Human Factors, and several papers for meetings were produced during the period of this contract.

A comprehensive series of reference manuals for the AN/SPA-66, for off-line study, also were produced, and are available for use in the Naval Training Commands if this is desired.

Abstracts of technical reports are reproduced below:

1. Technical Report 65: Specifications of Training Objectives for Computer-Aided Instruction, June 1970.

The specifications of training objectives, and the organization and implementation of courses around such objectives, is becoming a significant part of instructional technology.

In this report, there is a brief review of some of the background for this development in earlier, related activities of job and task analysis. Requirements for the specification of training objectives are discussed. The implications of data-processing technology for improved control over the specification and implementation of training objectives are illustrated in an example of how computer programs can generate criterion task specifications from relatively simple data bases, and compare student performance with these criterion tasks at a response-by-response level. Thus, where training is concerned with teaching task performance, both specification and implementation of training objectives can be considerably improved.

2. Technical Report 66: Measurement of Training Outcomes, June 1970.

Measurement of training outcomes is a requirement for evaluating new training techniques, but is one that is difficult to meet. Managers of education and training may have different concepts of what they want, as favorable outcomes, than do the investigators doing the research. Classical statistical and experimental designs assume laboratory rigor of control over variables that is seldom possible in the real world of a school or classroom. Yet in the broader perspective of educational institutions, the effectiveness of these institutions is a current issue of fundamental concern in our society. In this report, possibilities for measuring outcomes of training are surveyed, considering training as a form of planned social change. Approaches which are discussed include the classic Solomon four-group design, iterative adaptation to the peculiarities of individual student progress, response surface designs, adaptive control models, decision theory models, and simulation models. Illustrations from the CAI literature of recent attempts to measure training outcomes are given. The principal conclusions presented are that the classical four-way design is impracticable for most evaluation studies in training environments; that a policy of "adaptive research for big effects" is apt to be scientifically and administratively desirable; and that current attempts at measurement of training outcomes still use fairly simple methods.

3. Technical Report 67: Implications of Research on Internal Processing Operations in Learning and Memory for Serial Task Training, January, 1971.

The literature of learning research in which is internal processing operations of the learner were studied was reviewed. The current thinking of learning theorists regarding the nature and importance of these processes in learning and retention is described. The significance of this research for instructional technology is examined. It appears that this research marks the beginnings of a science of learning ability which may ultimately result in marked improvements in learning and retention. Verbalization, imagery, and organization engaged in by the learner during periods of rehearsal and self-initiated recall have been shown by theorists to have surprisingly strong positive effects on learning and retention. These internal processing operations, and selective attention, are worthy of immediate consideration by the instructional technologist. Two courses of action are suggested: programmatic research on these processes in the context of meaningful material, using appropriate "learning induction mechanisms," and reorientation of the goals and methods of instructional technology to give greater emphasis to learning to learn.

4. Technical Report 68: Motivating the Student in CAI Technical Courses, June, 1971.

Student motivation is a central issue in Computer-Aided Instruction (CAI), since even the most sophisticated teaching programs will require directed and sustained effort at the learning task. Technical students, who have to master long and difficult courses, present special motivational problems.

A review of the literature indicates that motivators for technical students can be classified under three main headings: (1) task-related or "intrinsic" factors, (2) need-related or "dynamic" determinants, and (3) external rewards. When viewed from a technical school framework, it appears that elements from each class of motivators are more or less manipulable and have not, so far, been fully exploited by CAI projects.

To illustrate the application of motivating factors, one potential system is proposed for immediate tryout in a military or industrial setting. The system classifies students according to certain dynamic variables such as need achievement. It also dispenses time-off from the training site as an immediate external reward for efficient learning, and includes a goal-setting participation by the student. It is believed that such a motivating system can be evaluated right now, by utilizing CAI drill programs in technical subject matter.

5. Technical Report 69: A General Purpose ASCII Decoder for Control of Peripheral Devices for CAI Terminals, January, 1972.

The ASCII decoder described in this report accepts inputs from an acoustic coupler, or Modem, in a remote time-sharing system. On receipt of a special command character the decoder recognizes, store and decodes the next two decimal digits. The output can be used to access any one of 100 items. For example, the decoder allows a random-access slide projector to be operated under computer control.

The report contains complete specifications, including a description of the functions of the circuits in the decoder.

6. Technical Report 70: Computer-Aided Performance Training for Diagnostic and Procedural Tasks, October, 1972.

Two computer programs for computer-aided performance training were developed. These programs were designed to give students the opportunity for concentrated practice of troubleshooting and of procedural tasks. In contrast to the usual approach taken in CAI, these programs simulate essential aspects of devices and tasks and continuously update their states during a practice session; they generate responses to a student's inputs from that student's history and simple list-structures; they are made specific to particular devices and tasks by data modules, therefore no "CAI language" is used; and they offer the student several options for drills and for receiving advice during practice.

These programs are being converted to run in a new type of programmable graphics terminal with two integral minicomputers. This terminal will be the basis for small "stand alone" CAI systems offering static and dynamic graphics, random-access photographic slides, and front panel simulators.

Publication

Rigney, J. W. and Towne, D. M. "TASKTEACH: A Method for Computer-Assisted Performance Training," Human Factors, 1970, 12(3), pp. 285-296.

A method for using a computer time-sharing system to assist the learning of serial tasks, from operating equipment to troubleshooting it, is described. The method is based on mediational theory. The current resurgence of interest in mediational theory in psychological research is noted, and parallels between experimental strategies and instructional strategies for evoking and manipulating mediating processes are pointed out. Categories of processes which mediate performance of serial tasks are described. Procedures for facilitating the learning of these processes are implemented by a computer program, called TASKTEACH. The program sustains the student's performance of complex serial tasks by giving him

variable amounts of support while helping him learn and organize the processes which mediate his performance of these tasks. The program generates output to the student during the learning session by processing short lists and the prior responses of the student. The lists, which are input to the program, replace the conventional frame-by-frame description of an instructional sequence written in a "CAI language."

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4 Dr. Marshall J. Farr
Director, Personnel and Training
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Army

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Arlington, Virginia 22209
ATTN: Dr. R. Dusek

1 Mr. Edmund Fuchs
BESRL
Commonwealth Building, Room 239
1320 Wilson Boulevard
Arlington, Virginia 22209

Air Force

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Wright-Patterson Air Force Base
Ohio 45433

1 AFHRL (TRT/Dr. Ross L. Morgan)
Wright-Patterson Air Force Base
Ohio 45433

1 AFHRL/MD
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1 CAPT Jack Thorpe USAF
Department of Psychology
Bowling Green State University
Bowling Green, Ohio 43403

DOD

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DOD Computer Institute
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Building 175
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Psychological Research Branch (P-1)
U.S. Coast Guard Headquarters
400 Seventh Street, SW
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Director for Manpower Research
Office of Secretary of Defense
The Pentagon, Room 3C980
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Other Government

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Personality and Cognition
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Behavioral Sciences Research
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Rockville, Maryland 20852

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Stanford, California 94305

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University of Rochester
Management Research Center
Rochester, New York 14627

1 Professor Mats Bjorkman
University of Umea
Department of Psychology
Radhuseplanaden 2
S-902 47 UMEA/SWEDEN

1 Mr. H. Dean Brown
Stanford Research Institute
333 Ravenswood Avenue
Menlo Park, California 94025

1 Dr. Jaime Carbonell
Bolt Beranek and Newman
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College of Arts and Sciences
River Campus Station
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4833 Rugby Avenue
Bethesda, Maryland 20014

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Montgomery College
Rockville, Maryland 20850

1 Dr. Robert Glaser
Learning Research and Development
Center
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Pittsburgh, Pennsylvania 15213

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American Institutes for Research
8555 Sixteenth Street
Silver Spring, Maryland 20910

1 Dr. Duncan N. Hansen
Center for Computer-Assisted Instruction
Florida State University
Tallahassee, Florida 32306

1 Human Resources Research Organization
Division #3
Post Office Box 5787
Presidio of Monterey, California 93940

1 Human Resources Research Organization
Division #4, Infantry
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U.S. International University
8655 E. Pomerada Road
San Diego, California 92124

1 Dr. E. J. McCormick
Department of Psychological Sciences
Purdue University
Lafayette, Indiana 47907

1 Mr. Luigi Petrullo
2431 North Edgewood Street
Arlington, Virginia 22207

1 Dr. Robert D. Pritchard
Assistant Professor of Psychology
Purdue University
Lafayette, Indiana 47907

1 Dr. Diane M. Ramsey-Klee
R-K Research & System Design
3947 Ridgemont Drive
Malibu, California 90265

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Department of Psychology
Montgomery College
Rockville, Maryland 20850

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Rowland and Company, Inc.
Post Office Box 61
Haddonfield, New Jersey 08033

1 Dr. Benjamin Schneider
Department of Psychology
University of Maryland
College Park, Maryland 20742

1 Dr. Robert J. Seidel
Human Resources Research Organization
300 N. Washington Street
Alexandria, Virginia 22314

1 Dr. Arthur I. Siegel
Applied Psychological Services
Science Center
404 East Lancaster Avenue
Wayne, Pennsylvania 19087

1 Dr. Benton J. Underwood
Department of Psychology
Northwestern University
Evanston, Illinois 60201

1 Dr. David Weiss
University of Minnesota
Department of Psychology
Elliott Hall
Minneapolis, Minnesota 55455

1 Mr. Edmund C. Berkeley
Berkeley Enterprises, Inc.
815 Washington Street
Newtonville, Maryland 02160

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Training Department
Hughes Aircraft Co.
P.O. Box 90515
Los Angeles, California 90009

1 Dr. Frank J. Harris
Chief, Training Division
U.S. Army Research Institute
1300 Wilson Boulevard
Arlington, Virginia 22209

1 LCOL Austin W. Kibler, Director
Human Resources Research Office
ARPA
1400 Wilson Boulevard
Arlington, Virginia 22209

1 Dr. Robert R. Mackie
Human Factors Research, Inc.
Santa Barbara Research Park
6780 Cortona Drive
Goleta, California 93017